Mammals of the Coastal Forests near Bega, New South Wales
I. Survey

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ABSTRACT

A survey of the mammals of the coastal State Forests, adjacent farmlands and coastal national park near Bega, on the south coast of New South Wales, was undertaken between 1979 and 1984. A total of 39 native and 10 exotic species was found in the area surveyed. That 17 (44%) of the native species were bats demonstrates the importance of considering this order of mammals in both future surveys and forest management. The presence of species varied according to the land-use category of the area surveyed. State Forest was richest and contained 37 of the 39 native species found. Coastal national park supported 17 native species, while only 7 were found on farmland. Of the 39 species, 14 were considered rare in the survey area, 11 were uncommon and 14 common. Of the twelve methods of detection used, the most productive was predator scat analysis, which yielded 24 native species and 9 exotic species. The survey was conducted using a wide variety of detection methods in logged and unlogged, burnt and unburnt forest and through drought years. Observations were made about the impact of logging, fire and drought on native mammals and proposals made for their conservation and management.

INTRODUCTION

Since 1976 the State Forests of the Bega district on the south coast of New South Wales have been subjected to integrated logging for pulpwood and sawlogs. The scale of operations of integrated logging is much greater than that of selective logging, which had been carried out by local sawmillers since settlement of the Bega district in 1830. In 1916, the State Forests of the district were declared and placed under the management of the Forestry Commission. The State Forests occur on the mountains surrounding the Bega Valley, where most of the forest habitat had been cleared for farming by the turn of the century. The State Forests now serve as an important refuge for the mammal fauna of the district. Essential to the long-term conservation of mammal fauna in the State Forests is a detailed knowledge of the species present, their habitat requirements, and the effect of logging on individual species.

This paper presents the mammal survey component of a five-year study (1979-84) of the effects of logging on the fauna of the coastal State Forests near Bega. The aim of the survey was to determine the distribution, status and habitat preferences of all mammal species in these forests as well as on adjacent farmland and on the coastal strip of National Park. Prior to 1979 there were no other studies of the fauna of the coastal forests near Bega, but information was available from Nadgee Nature Reserve, 60 km to the south (Fox 1978). Further information about the fauna of Nadgee Nature Reserve and adjacent forests became available after commencement of this study (Recher *et al.*1980, Newsome *et al.* 1983, Braithwaite *et al.* 1984). Studies of possums and gliders throughout the Bega, Bombala and Eden districts by Braithwaite (1983) included a survey of the coastal State Forests near Bega. The neglected mammal group in all published studies was the bats, yet judging from the distribution maps in Strahan (1983), there was reason to believe that about one-third of the mammal species found in the forest would be bats. Special emphasis was given to this group of mammals in this study because many species roost in trees, and tree-dwelling fauna has been recognized as a group adversely affected by logging (e.g. Tyndale-Biscoe and Calaby 1975, Recher *et al.* 1980). We also present information on the effects on mammal fauna of fire and drought, both of which occurred during the study period.

STUDY AREA

The study area was the coastal forests and farms near Bega on the south coast of New South Wales. It has been described by Lunney and Barker (1986a) in a survey of the reptiles and amphibians of the area. It comprised Mumbulla State Forest (9089 ha), the coastal Mimosa Rocks National Park and its extension westward along Nelson Creek into the former Tanja State Forest, and adjacent farmland, particularly the area enclosed by State Forests and the coastal National Park. In this study the westward extension of Mimosa Rocks National Park is referred to as Tanja State Forest to differentiate it from the coastal National Park because this survey was commenced prior to its dedication in 1982.

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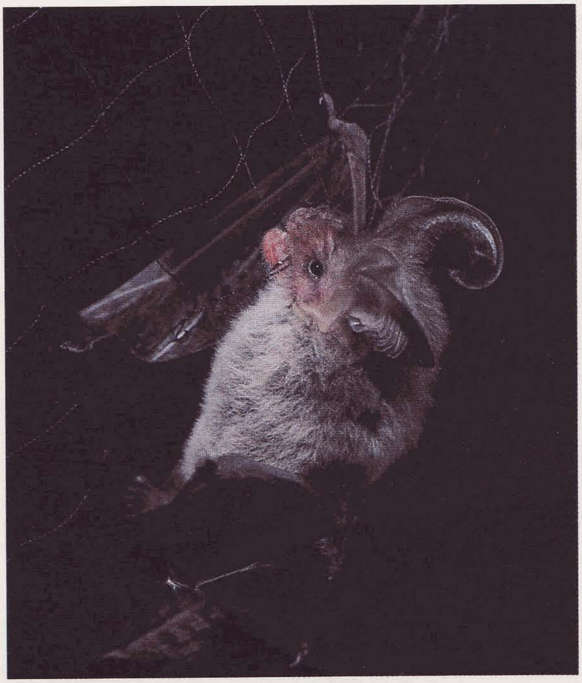

Fig. 1. Gould's Long-eared Bat *Nyctophilus gouldi* caught in a mist net. These bats need to be taken from the net within minutes of capture. Otherwise they may chew through it and escape. — Daniel Lunney

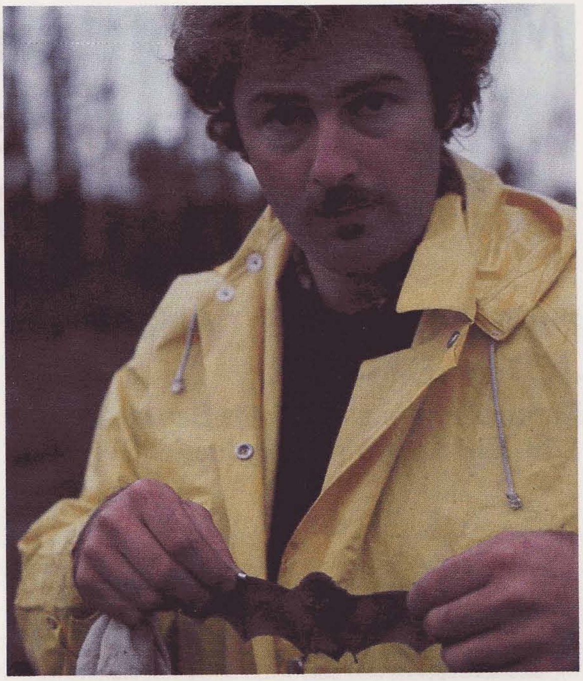

Fig. 2. The Chocolate Wattled Bat *Chalinolobus morio* held by bat expert Harry Parnaby. This 8 g bat is a typical size for most of the insectivorous species in this study. Note the band, which carries an individual number, on the forearm. — Daniel Lunney

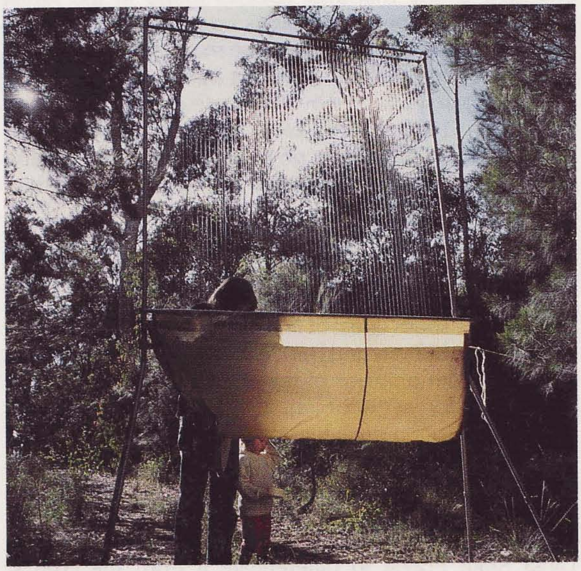

Fig. 3. A harp trap, which proved to be effective in trapping the insectivorous forest bats. Note the double bank of softly-strung nylon lines, which the bats fly into and fall into the bag below. — Daniel Lunney

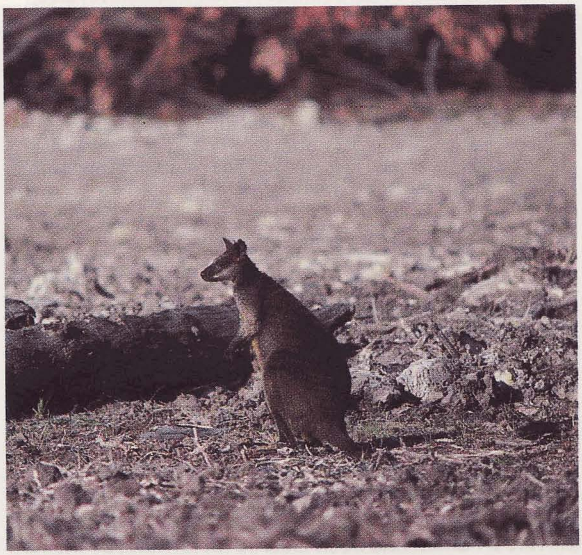

Fig. 4. The Swamp Wallaby *Wallabia bicolor* was the commonest macropod in the area. It occurred throughout the forest, and emerged from the forest edge onto farms at dusk. Here it was feeding on ploughed farmland next to Mimosa Rocks National Park. — Daniel Lunney

Mumbulla and Tanja State Forests are open forests dominated by Silver-top Ash *Eucalyptus sieberi* and Stringybarks *E. muellerana, E. globoidea* and *E. agglomerata*. Other species present are Monkey Gum *E. cypellocarpa*, Coastal Grey Box *E. bosistoana*, Woollybutt *E. longifolia*, Red Ironbark *E. sideroxylon* and Spotted Gum *E. maculata* along Nelson Creek. The coastal strip of Mimosa Rocks National Park consists principally of low open forest, with banksia heaths and grassy patches.

In November 1976 integrated logging for pulpwood and sawlogs began in Tanja State Forest. This ceased in early 1977 when logging operations moved to Mumbulla State Forest, which was logged until 1983. Details of the logging operation are in the Eden Native Forest Management Plan (Forestry Commission of NSW 1982). A feature of the plan is to log the forest in small coupes or cutting areas, which between 1976 and 1983 were typically 10-20 ha. Alternate coupes are logged in 20-year cycles. After the first cycle (1976-83), when the first set of coupes was logged, the forest had a chessboard appearance of alternating logged and unlogged coupes. Between 1964 and 1972, a strip in the southern half of Mumbulla State Forest was clearfelled from west to east. This operation, which felled about 13% of the forest, was carried out for Timber Stand Improvement (TSI) to eliminate non-commercial trees and produce a stand of straight, millable sawlogs. TSI operations were replaced by integrated logging operations with the advent of the woodchip industry.

Half of Mumbulla State Forest was burnt by a bushfire that began on 18th November 1980. Prior to this fire, the forest had not burnt for about 40 years except for regular control burns, low fires from the west in 1952, and a fire in part of the TSI in 1968 (E. Dowton, 1982, pers. comm., Forestry Commission Foreman 1953-76, Mumbulla State Forest). On 3rd October 1981 the western portion of Tanja State Forest was burnt. From February 1980 to May 1983 the district experienced the worst drought on record for southeastern New South Wales (Bureau of Meteorology 1983).

METHODS

The study began in July 1979 and ended in December 1984. A variety of methods was used to maximize capture and detection of different species.

1. Trapping

i) Aluminium box traps (Elliott Scientific) folding 8 × 10 × 33 cm. These were set to catch small ground-dwelling mammals throughout all habitats in the State Forests as survey lines (usually 20 traps per line set for 3 days), or in association with specific studies (Lunney *et al.* 1986, Lunney *et al.* 1987, Lunney and Ashby in press), for a total of 76,000 trap-nights from August 1979 to December 1984.

ii) Wire cage traps (60 × 20 × 20 cm) were set in all habitats in the State Forests and the coastal National Park on a total of 700 trap-nights between 1980 and 1983 to catch medium-sized ground-dwelling mammals.

iii) Pitfall traps, set as part of a study of the White-footed Dunnart *Sminthopsis leucopus*, were set for 200 trap-nights in December 1984 in a recently logged part of the forest.

iv) Harp traps were set in all forest habitats, including the coastal strip of Mimosa Rocks National Park, on 1300 trap-nights from November 1981 to December 1984.

v) Mist nets were used to trap bats on 460 net-nights from November 1981 to March 1983 in all habitats in Mumbulla State Forest.

2. Analysis of mammals remains in dog and fox scats. A total of 2249 canivore scats were collected from July 1981 to August 1982. The techniques of hair analysis of Brunner and Coman (1974) and Triggs *et al.* (1984) were used to identify mammal species eaten as prey or carrion.

3. Spotlighting for arboreal marsupials using hand-held portable spotlights was carried out on 214 person-nights between August 1979 and May 1983 in al! habitats (Lunney in press).

4. Others

i) Sighting of live animals.
ii) Road kills.
iii) Vocalizations.
iv) Dung identification (as shown in Triggs 1984).
v) "Sign" identification of species by diggings, remains, nests or tracks.
vi) Observations by logging crews in Mumbulla State Forest in July 1979 for 10 days.
vii) Nets and spotlights were used to survey for platypus in December 1982.

The total field effort was 457 person weeks, with 9 weeks in 1979, 28 weeks in 1980, 153 weeks in 1981, 148 weeks in 1982, 93 in 1983 and 26 in 1984. Most of the survey was carried out in Mumbulla and Tanja State Forests both before and after fire, with similar search effort in logged and unlogged coupes and TSI. Gullies and ridges were searched with equal effort.

Mammals recorded during the study were assigned a status based on their distribution and abundance. There were three ranks: common (a species regularly recorded over a wide area); uncommon (a species recorded only occasionally, even though it may have been abundant in a restricted area); and rare (a species recorded only infrequently and never abundant in any area). In this paper, the nomenclature of both scientific and common names follows Strahan (1983).

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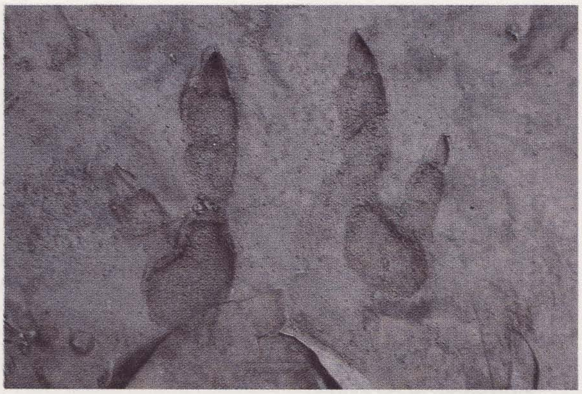

Fig. 5. These footprints in mud beside a forest road identify the presence of the Red-necked Wallaby *Macropus rufogriseus.* — Daniel Lunney

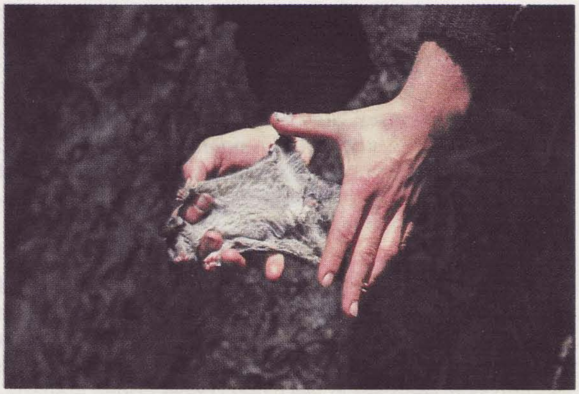

Fig. 7. The underside of the Sugar Glider *Petaurus breviceps* showing the gliding membranes. — Daniel Lunney

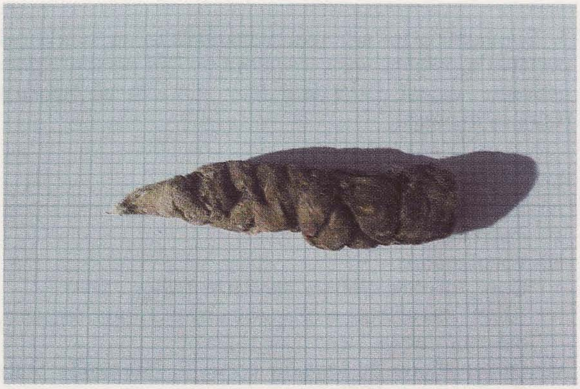

Fig. 6. Characteristic scat of the Spotted-tailed Quoll *Dasyurus maculatus* on 2 mm graph paper. This scat was the sole evidence for the occurrence of this species in the study area. It contained grooming hairs of *D. maculatus*, which confirmed the identification. — Daniel Lunney

Fig. 8. Sugar Glider *Petaurus breviceps* gliding between trees. — Daniel Lunney

RESULTS

Species and Status

Table 1 provides a summary of habitats and status of the 49 (39 native, 10 exotic) species of mammals found during the study. Further details, including methods of detection of mammals recorded during the survey, are presented in an annotated checklist, which is part II of this paper (Lunney and Barker 1987). Of the native species, 14 were rare, 11 were uncommon and 14 were common. Of the exotic species, 3 were rare, 1 was uncommon and 6 were common. Of the three land-use categories, forest was the richest with 37 of the 39 native species found. The coastal National Park supported 17 native species, while only 7 were found on farms. All native species found on farms occurred in the forest, whereas two species found in the coastal National Park (Large-footed Mouse-eared Bat *Myotis adversus* and Water Rat *Hydromys chrysogaster*) were not found elsewhere.

Methods of Detection

Table 1 also shows results of the 12 methods of detection used. The most productive was predator scat analysis, which yielded 24 native and 9 exotic species, and detected the presence of 2 native and 1 exotic species not detected by any other method. Harp traps and mist nets together caught 16 of the 17 species of bats. Only 7 species of bats were detected by means other than harp traps and mist nets. Dung analysis indicated the presence of 6 native, and 5 exotic species. Sign identification yielded 8 native species and 1 exotic species. Together with dung identification, the two methods together yielded 10 native and 5 exotic species. By contrast, observation accounted for 11 native and 6 exotic species. No individuals of any species were found burnt or dead as a result of fire, despite an intensive search of the burnt Mumbulla State Forest in late November and early December 1980.

Ground-dwelling Small Mammals

Pre-fire surveys (before 18 November 1980) of small ground-dwelling dasyurids and rodents indicated a typical species composition for south coast forests with the interesting addition of a population of *Sminthopsis leucopus.* The number of the Brown Antechinus *Antechinus stuartii* and the Bush Rat *Rattus fuscipes* was sharply reduced by the fire of November 1980, with the Dusky Antechinus *Antechinus swainsonii* becoming locally extinct in burnt areas. The rate of recovery of *A. stuartii* and *R. fuscipes* was retarded by the drought. The exception was *S. leucopus,* which utilized the logged, burnt areas for two years after the fire (Lunney *et al.* 1987, Lunney and Ashby in press).

Possums and Gliders

Seven species of possums and gliders were found during the survey. The relative frequency of each species varied with the detection method used. For example, the large possums (Brushtail Possum *Trichosurus vulpecula* and the Ringtail Possum *Pseudocheirus peregrinus*) were recorded more frequently by scat analysis than by spotlighting, whereas the large gliders (Greater Glider *Petaroides volans,* Yellow-bellied Glider *Petaurus australis,* and the Sugar Glider *P. breviceps*) were seen more often than they were detected in dog and fox scats. Both of the small species (Feathertail Glider *Acrobatus pygmaeus* and Eastern Pygmy Possum *Cercartetus nanus*) were rarely recorded. Most sightings of possums and gliders were in unlogged gullies, and to a lesser extent in logged gullies. Only two species, *P. breviceps* and *P. peregrinus,* were seen in the TSI. Most sightings were in large (60 cm + diameter at breast height over bark) trees. Possums and gliders were seen less frequently in logged than unlogged coupes and were rarely seen in the intensively burnt parts of the forest.

Medium and Large Ground-dwelling Mammals

Despite intensive trapping, bandicoots were rarely caught in the State Forest. The Long-nosed Bandicoot *Perameles nasuta,* however, was common in a few highly restricted areas of the sandy coastal strip of Mimosa Rocks National Park. The Southern Brown Bandicoot *Isoodon obesulus* was recorded only once by its occurrence in a Spotted-tailed Quoll *Dasyurus maculatus* scat. It is now considered a rare species in NSW (Ashby *et al.* in press).

The Long-nosed Potoroo *Potorous tridactylus* was detected only in scats. Three other species of macropodids, the Grey Kangaroo *Macropus giganteus,* Red-necked Wallaby *M. rufogriseus* and Swamp Wallaby *Wallabia biocolor* were seen both pre- and post-fire, and the latter two species were the most commonly seen of all mammal species. They were also two of only four native species to occur in all habitats surveyed. The Common Wombat *Vombatus ursinus* was uncommon in the forests, as judged from the frequency of its droppings. It was seen only once in the forest and was never seen on the adjacent farmland.

Bats

Seventeen species of bats were recorded, including the rare Golden-tipped Bat *Phoniscus papuensis* (Lunney and Barker 1986b). All species were caught by the end of the first summer of trapping. Two obligate cave-roosting species, the Common Bent-wing Bat *Miniopterus schreibersii* and the Eastern Horseshoe-bat *Rhinolophus megaphyllus,* occupied abandoned shafts of gold mines (one in Tanja State Forest, the other in Mumbulla State Forest). No other species was seen in the mine shafts. The drought had a severe effect on all species, the numbers declining considerably between the initial survey in the summer of 1981-82 and the following summer. The number of species declined from 6 to 3 in one survey area, and the number of individuals from 89 to 31. Grey-headed Flying-foxes *Pteropus poliocephalus* were sighted on only one occasion (April 1984) when a temporary camp of about 1000 individuals was seen in Bermagui State Forest, about 15 km to the north of the study area. Hair of this species was found in five dog and fox scats in the study area in 1981 and 1982.

Exotic Species

Dog *Canis familiaris* and Fox *Vulpes vulpes* scats were abundant and indicated much higher numbers present than suggested by direct observation. Packs of dogs were seen on several occasions. Only two cats *Felis catus* were seen. The stomach of one contained a lizard and a bird. Rabbit *Oryctolagus cuniculus* were more common after the fire, and cattle *Bos taurus* frequently strayed into the forest. Pigs *Sus scrofa* were detected only by the presence of one pig scat, and pig hair in four predator scats, while sheep *Ovis aries,* which were seen only once in a small mob in 1984 in the TSI, were commonly detected in predator scats. Whether feral individuals of pig or sheep were present in the forest or taken on farms is not known, and whether the pig scat was from a straying farm animal is not known. The House Mouse *Mus musculus* was rare

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	HABITATS								STATUS		
	State Forest							Coastal			
	unlogged		logged		TSI		Cleared	National			
Species	ub	b	ub	b	ub	b	farms	Park	R	UC	C
Native Species											
Tachyglossus aculeatus	*	*	*	*	*	*	*	*			*
Dasyurus maculatus						*			*		
Antechinus stuartii	*	*	*	*	*	*		*			*
A. swainsonii	*		*		*						*
Sminthopsis leucopus	*	*	*	*							*
Perameles nasuta	*	*						*		*	
Isoodon obesulus						*			*		
Vombatus ursinus	*	*	*	*	*	*					*
Pseudocheirus peregrinus	*	*	*	*	*	*				*	
Petauroides volans	*	*	*								*
Petaurus australis	*	*	*					*		*	
P. breviceps	*	*	*	*	*		*	*			*
Trichosurus vulpecula	*	*	*	*			*			*	
Cercartetus nanus				*			*		*		
Acrobates pygmaeus	*								*		
Potorous tridactylus	*								*		
Macropus rufogriseus	*	*	*	*	*	*	*	*			*
M. giganteus	*	*	*	*	*	*				*	
Wallabia bicolor	*	*	*	*	*	*	*	*			*
Pteropus poliocephalus	*								*		
Rhinolophus megaphyllus	*	*	*	*	*	*		*			*
Tadarida australis	*	*	*	*	*	*	*	*			*
Mormopterus loriae	*			*					*		
Nyctophilus gouldi	*	*	*	*	*	*		*			*
N. geoffroyi	*	*	*	*	*	*		*			*
Miniopterus schreibersii	*	*	*	*	*	*		*			*
Chalinolobus gouldii	*	*	*	*	*	*				*	
C. morio	*	*	*	*	*	*					*
Myotis adversus								*	*		
Nycticeius orion	*					*			*		
N. rueppelli	*	*	*	*	*	*				*	
Phoniscus papuensis				*	*	*			*		
Pipistrellus tasmaniensis	*	*	*	*	*	*				*	
Eptesicus regulus						*		*	*		
E. sagittula	*		*	*	*	*			*		
E. vulturnus	*	*	*	*	*	*		*			*
Hydromys chrysogaster								*	*		
Rattus fuscipes	*	*	*	*	*	*		*			*
R. lutreolus				*					*		
Sub-total	31	24	25	26	22	24	7	17	14	11	14
Exotic Species											
R. rattus				*					*		
Mus musculus	*	*	*	*		*	*				*
Oryctolagus cuniculus	*	*	*	*		*	*	*			*
Lepus capensis							*		*		
Canis familiaris	*	*	*	*	*	*	*	*			*
Vulpes vulpes	*	*	*	*	*	*	*	*			*
Felis catus				*	*		*	*			*
Bos taurus		*		*	*	*	*				*
Ovis aries						*	*			*	
Sus scrofa						*			*		
Sub-total	4	5	4	7	6	7	8	4	3	1	6
TOTAL	35	29	29	33	28	31	15	21	17	12	20

Table 1. The habitats, status and methods of detection for the mammals found in the study area. (ub = unburnt, b =burnt, TSI = Timber Stand Improvement, 10-20 year regrowth forest). The status is: R = rare; UC = uncommon; and C = common. The code numbers for the methods of detection are: 1. aluminium box trap; 2. pitfall trap; 3. cage trap; 4. harp trap; 5. mist net; 6. spotlight; 7. observation; 8. identification of dung; 9. identification of hair in predator (Dog, Fox, Quoll) scat; 10. sign: identification of diggings, nests, tracks, and mammal remains; 11. vocalizations; 12. dead on road.

METHODS OF DETECTION											
1	2	3	4	5	6	7	8	9	10	11	12
						*	*	*	*		*
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9	2	2	15	13	9	11	6	24	8	3	4
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						*	*	*			*
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							*	*			
2	0	0	0	0	2	6	5	9	1	1	1
11	2	2	15	13	11	17	11	33	9	4	5

except in burnt forest, its numbers reaching plague proportions from April to June 1982, a period which corresponded to the only respite in the 1980-83 drought (Lunney *et al.* 1987). Three individuals of the Black Rat *Rattus rattus* were caught in June 1983 in Mumbulla State Forest.

Platypus

Extensive netting in creeks and rivers did not reveal the presence of platypus *Ornithorhynchus anatinus* in the coastal forests. However, discussions with inspectors from State Fisheries and local residents (Tom Grant pers. comm. 1981) determined that it was present in the Brogo River and in creeks and rivers of the Bega Valley immediately to the west of the coastal forests. These creeks and rivers were predominantly in farmland.

Koala

Despite intensive searching, Koalas *Phascolarctos cinereus* were not seen in the study area. However, Forestry Commission Foremen J. Geall and T. Wills reported the presence of two individuals in 1984 in Bermagui State Forest 15 km to the north. These were presumed to be survivors, or progeny of survivors, from re-introductions by T. Wills of about 10 Koalas displaced by the logging of the local forests between the 1930s and 1950s.

DISCUSSION

Methods of Detection

The survey showed that it was necessary to use a range of techniques to detect all mammal groups present. The hair analysis of scats proved to be the most efficient survey technique for all mammal groups, except bats, and was particularly valuable for rare species. A total of 33 species was recorded by this method, far more than by any other, and 3 species, *Potorous tridactylus, Isoodon obesulus* and Brown Hare *Lepus capensis* were not detected by any

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other means. This agrees with the conclusion of Brunner and Wallis (1986) in their review of the efficiency of a variety of mammal survey techniques, and confirms the limitation of this method for microchiropterans.

The intensity of the search effort (457 person weeks) over five years with a wide variety of methods through all habitats allows the reasonable conclusion to be drawn that all species present in the study area during the period of study (1979-84) were found.

Status of Species

Since all groups of mammals were detected by a range of methods over a long period, we conclude that the status (rare, uncommon, common) assigned to species found is a realistic reflection of their relative abundance, with one exception (*Acrobates pygmaeus*). On this basis, we are able to state confidently that *Phascolarctos cinereus* was not present in the study area but was in the Bega district. The known presence of *Ornithorynchus anatinus* in the rivers and creeks of the Bega Valley, and the finding of the Little Red Flying-Fox *Pteropus scapulatus* near Bermagee Nature Reserve about 10 km to the north (Rose 1981) also confirm their presence in the Bega district.

Of the 39 native species found, two (*Phoniscus papuensis* and *Sminthopsis leucopus*) are classified as vulnerable, endangered and rare under the NSW National Parks and Wildlife Act (1974). The details of captures and habitat of *P. papuensis* are given in Lunney and Barker (1986b). The high number of *S. leucopus* presented the opportunity to study how this species survived and bred in a logged, burnt forest (Lunney *et al.* 1986, Lunney *et al.* 1987 and Lunney and Ashby in press).

Of the 39 native species, 14 were regarded as rare in the study area, with two species (*Isoodon obesulus* and *Dasyurus maculatus*) being recorded only once. The forest and the coastal National Park did not carry much suitable habitat for either the Swamp Rat *Rattus lutreolus* or *Hydromys chrysogaster.* Farms now occupy what would once have been prime habitat for these species. *Potorous tridactylus* was recorded from only 11 dog and fox scats, and despite 700 trap-nights with cages placed in runways through the ground-storey vegetation in the forest, none was caught. As this species in Nadgee Nature Reserve was not considered difficult to trap in cage traps (Lunney, pers. observ.), the failure to trap it in Mumbulla State Forest was taken as a reflection of its rarity. Further confirmation of its presence in the district comes from Rose (1981), who caught one in 1980 near Bermagee Nature Reserve 10 km to the north of the study area.

Acrobates pygmaeus was classed by us as rare, but Braithwaite's (1983) results indicate that it was more common than our records revealed. His method of asking logging crews to report possums and gliders dislodged from felled trees yielded 64 records of *A. pygmaeus* from 900 hectares in Mumbulla and Tanja State Forests. This indicates that this species was not rare, and also points to the importance of utilizing as many different methods as possible in determining distribution and relative abundance of mammals in a forest.

The remaining seven rare species were bats. *Pteropus poliocephalus* was classified as rare because it was located only in 4 scats, and none was seen. However, a temporary camp in Bermagui State Forest showed that it does move through the district. Similarly, the presence of a specimen of *P. scapulatus* about 10 km to the north (Rose 1981) shows that this species also occurs in the district, although it was not detected in the study area. Whether *Myotis adversus* was as rare as the single individual caught would indicate, or whether it is a species strictly confined to coastal lagoons, was not determined. Although another five species of bats are widespread elsewhere (Strahan 1983), the survey shows them to be rare in this locality. The sampling methods in this study, of setting harp traps and mist nets near ground level, may not have adequately recorded the presence of such high-flying species as the Little Northern Mastiff Bat *Mormopterus loriae*

Exotic Species

Of the 10 exotic species found, 2 species (*Canis familiaris* and *Vulpes vulpes*) occurred throughout the study area and consistently preyed on native species. The other exotic species, except for *Mus musculus* which plagued in the heavily burnt forest, were uncommon or rare in the forest. The rarity of *Felis catus* in the forest, and their common status on farms, suggests either that they were rare in the forest, or just far less visible. The presence of *Lepus capensis* in the area was detected only by hair in scats, and the presence of *Sus scrofa* in the forest only by pig dung and hair in scats. This suggests that both species are rare in the area. Similarly, the fact that only three individuals of the Black Rat *Rattus rattus* were detected, and then only in the third winter after the fire, indicates that this species was rare in the forest. *Oryctolagus cuniculus*, although common on nearby farms, was much less common in the forest.

Tree-dwelling Species

The arboreal marsupials were adversely affected by woodchip logging (Lunney in press). Only two species (*Pseudocheirus peregrinus* and *Petaurus breviceps*) existed in the virtually clearfelled TSI forest of 10-20 years' regrowth in Mumbulla State Forest. The present logging operation is removing most of the mature hollow-bearing trees which provide food and shelter not only for possums and gliders but also for bats (e.g. Hall and Richards 1979, Lunney *et al.* 1985). The forests support 17 species of bats, including *Phoniscus papuensis*, one of the rarest bats in Australia. As 15 of the 17 species are tree-roosting bats, continued logging in the area will further reduce the number of trees suitable for maternity roosts and may bring about local extinctions of some species.

Comparison with other Studies

The work of Fox (1978), Recher *et al.* (1980), Newsome *et al.* (1983) and Braithwaite *et al.* (1984) in the Eden district immediately to the south of the Bega district shows a similar species composition to that found in this study. None of these studies had specifically trapped for bats, which constituted 44% of native mammal fauna in this survey. Since bats in this survey contributed such a high proportion of the mammal species found, and are thus a major component of local mammal fauna, their requirements must be taken into account in forestry management if they are to be adequately conserved.

Other differences exist between this study and the Eden studies. Of particular interest are the rare animals. *Phascolarctos cinereus* was recorded in Nadgee Nature Reserve (Newsome *et al.* 1983), and in Yurammie State Forest in 1978-9 in the Eden district (Best 1980). The conclusion to be drawn is that the Koala, which did not occur in the study area, is rare in the Bega district. *Isoodon obesulus*, which was recorded only once in the study area, was caught in low but steady numbers over a period both in and near Nadgee Nature Reserve 60 km to the south (D. Spratt, CSIRO, pers. comm. 1985). This suggests that the rarity of *I. obesulus* in the Bega district could be attributed to habitat changes since settlement, which have been more extensive than in the Eden district. *Sminthopsis leucopus*, recorded in high numbers in this study, was recorded only occasionally in the Eden studies. However, in a pitfall study by the Forestry Commission of NSW in the Bombala district, to the south-west of the Bega district, 30 *S. leucopus*, principally juveniles, were caught (G. Webb, Forestry Commission, pers. comm.). *Potorous tridactylus* was reported from the Eden district and, as in the Bega district, was present in low numbers.

Impact of Fire and Drought

The impact of fire was most marked on *Antechinus swainsonii* (Lunney *et al.* 1987). It was absent from the forest for over two years following the fire. The common ground-dwelling species, *Antechinus stuartii* and *Rattus fuscipes*, were uncommon and even rare in burnt areas. Further, the drought kept their populations at a low level. In the intensively burnt areas *Mus musculus*, normally a rare species in the forest, reached a plague in 1982. *Sminthopsis leucopus* was present in the alternate-coupe logged forest in Mumbulla State Forest, but was never present in the TSI (Lunney *et al.* 1987). It continued as a breeding population in the burnt forest, principally on the logged ridges, for only two years (Lunney and Ashby in press), and was then only present in recently disturbed sites and road edges in December 1984. Possums and gliders were rarely seen in burnt forest (Lunney in press), and fewer bats of fewer species were caught in the intensively burnt TSI along Wapengo Creek than on the lightly burnt, or unburnt TSI ridges. The drought reduced the numbers of possums, gliders (Lunney in press) and bats in the summer of 1982-83. Since the greatest numbers of both individuals and species of these two groups were located in the unburnt unlogged gullies, it indicates that unlogged gullies provided the best refuge against drought and therefore are the best areas to set aside from logging for the conservation of these mammals.

Wildlife Conservation and Management

The intensity, duration and scope of this survey, which also draws upon the results of a number of specific studies (Lunney in press, Lunney *et al.* 1985, Lunney and Barker 1986a,b, Lunney *et al.* 1986, Lunney *et al.* 1987, Lunney and Ashby in press), enables us to propose strategies for the conservation of mammals of intensively logged forests.

The forests on the hilly country of the study area are surrounded by the agricultural land of the valleys, which were cleared by the end of the last century. These remaining forests serve as a vital refuge for the fauna of the district. The conservation of mammals in these forests will depend on the retention of as much suitable habitat as possible. The large stretches of agricultural land may, for many species, prevent recruitment from elsewhere. Further pressures on already depleted populations may lead to local extinctions. Forestry management plans should allow for the retention of large unlogged areas, particularly in gullies where the most suitable habitat for the widest range of mammal species was found. Further, the impact of fire on mammals should be recognized and management practices should continue to be reviewed to help reduce fire frequency. Also, controlled burning should be kept to a minimum. At the end of the first logging cycle in 1983, about half of the forest had been logged as small, alternate coupes.

If current logging plans (Forestry Commission of NSW 1982) are adhered to, the greatest impact of logging on the fauna can be expected following the second logging cycle around the turn of the century. At that stage, the forest will consist mainly of small alternate coupes with about 20 year-old regrowth, recently logged coupes and TSI with about 30-40 years of regrowth. For those species dependent on mature, unlogged forest, there will be only a small and fragmented area of suitable habitat. At this point there will be an increased likelihood of local extinction of these species.

To assist in minimizing reduction in population sizes and the possibility of extinctions, certain areas, selected on faunal values, including such habitat criteria as large, hollow-bearing trees, should be set aside from logging. Further, the concept of buffer strips (Forestry Commission of NSW 1982) should be expanded, and gullies should be redefined to include all drainage lines and

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remain unlogged so that continuous stretches of the larger gully trees are retained as well as the denser, moister undergrowth. The gullies most important to retain are those least likely to burn or be affected by drought. Also, the status of mammal populations should be regularly evaluated to assess changes, and alternative logging prescriptions instituted if particular species appear to be at risk.

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